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Dassanayake

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(54) **CROSSED ROLLER BEARING**

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(Continued)

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CPC ***F16C 19/362*** (2013.01); ***F16C 33/37*** (2013.01); ***F16C 33/6629*** (2013.01); *F16C 33/6614* (2013.01)

(58) **Field of Classification Search**
CPC F16C 19/362; F16C 33/37; F16C 33/6629; F16C 33/6614
See application file for complete search history.

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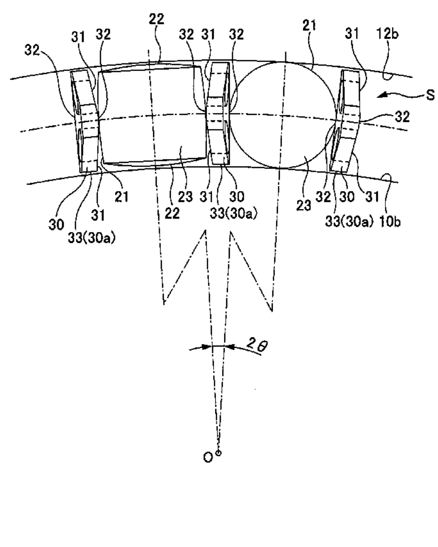
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

A crossed roller bearing, including: an inner element and an outer element that relatively rotate, the inner element including an annular inner V-groove that is provided along an outer peripheral surface of the inner element and that has a V shape that opens towards the outer element, the outer element including an annular outer V-groove that is provided along an inner peripheral surface of the outer element, that has a V shape that opens towards the inner element, and that faces the inner V-groove; a plurality of cylindrical rolling elements that are placed between the inner V-groove and the outer V-groove, that roll while being in contact with the inner V-groove and the outer V-groove, and adjacent rolling elements of which have rolling axes that are perpendicular to each other; and a retainer that are placed between the adjacent rolling elements that includes a flat section that is a projecting central section on an area which faces either one of the rolling elements and that is capable of contact with the rolling element, and a tilt section whose degree of projection becomes smaller as it goes from the flat section to an end section of the retainer.

7 Claims, 7 Drawing Sheets



(51) **Int. Cl.**
F16C 33/37 (2006.01)
F16C 33/66 (2006.01)

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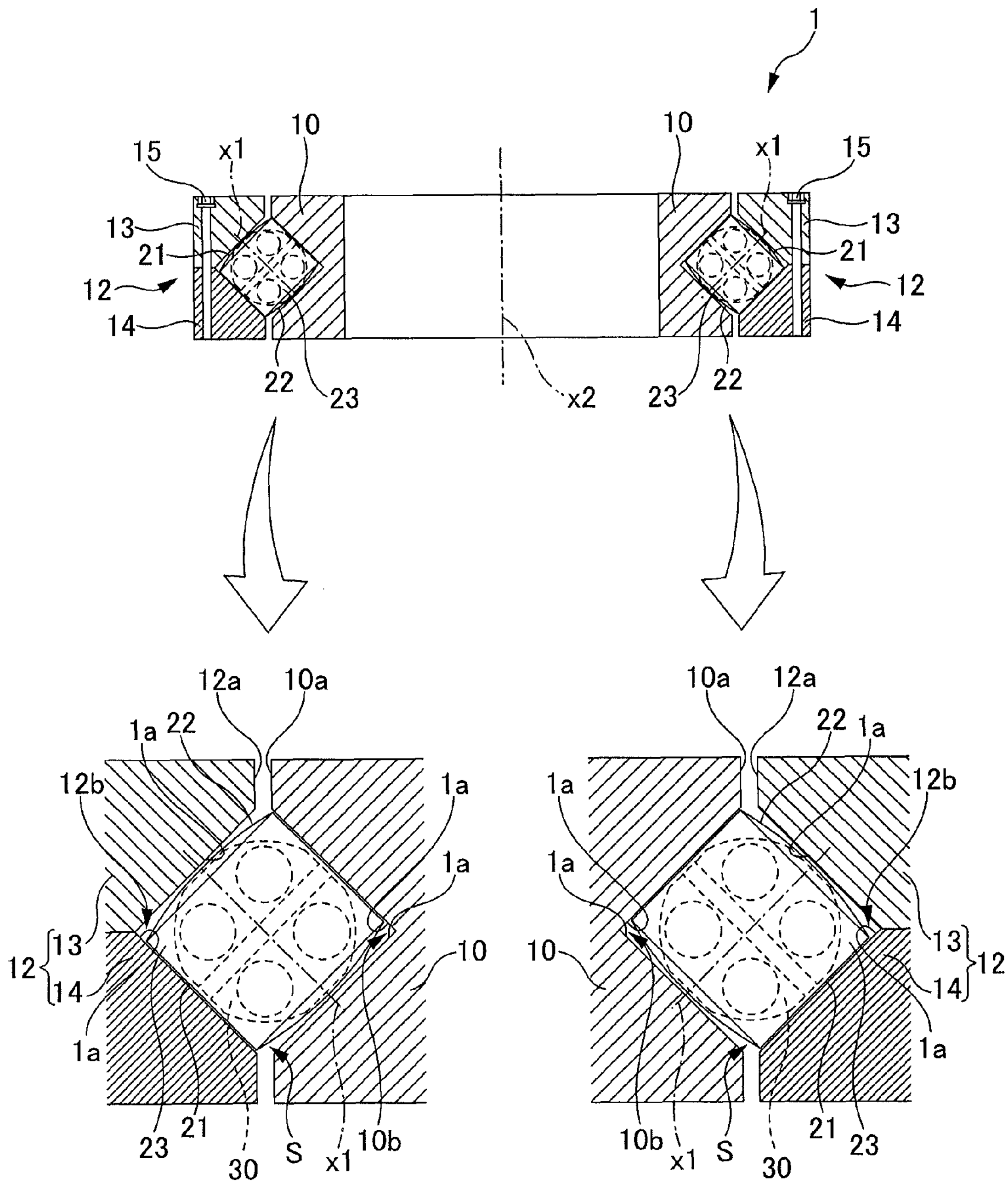


FIG. 1

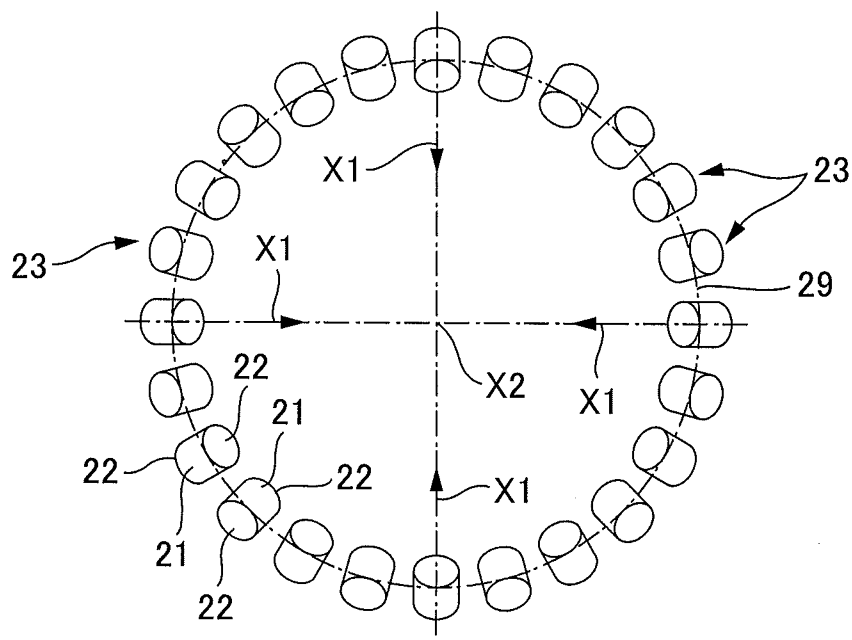
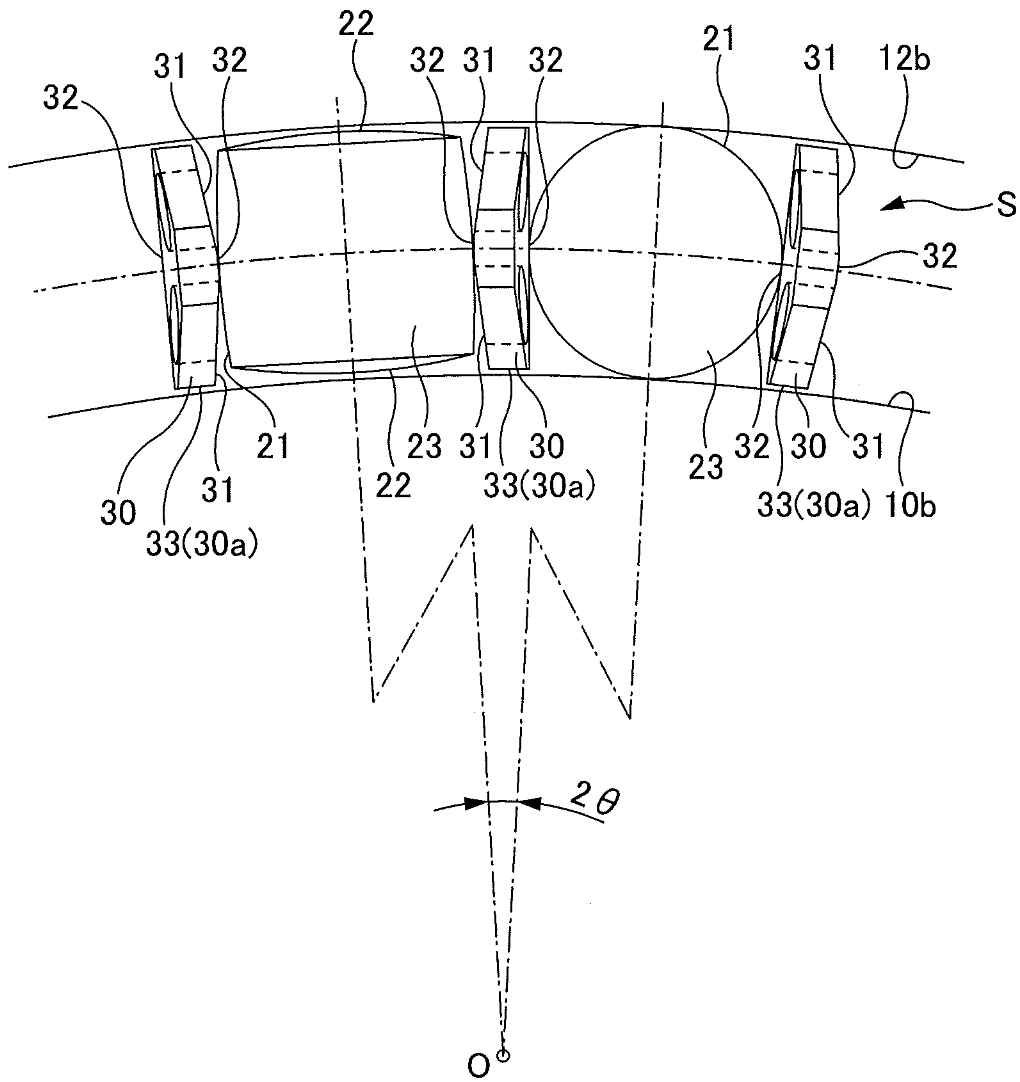


FIG. 2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21
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12b
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31
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32
S
32
30
33(30a)
31
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33(30a)
23
32
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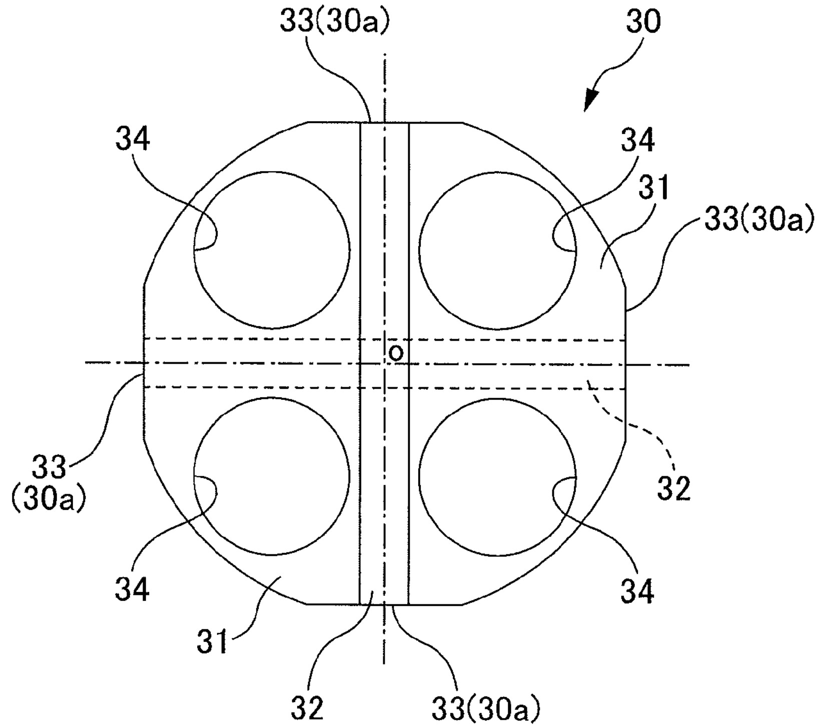
31
33(30a)
10b
2θ
O

FIG. 3


33(30a)
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33(30a)
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(30a)
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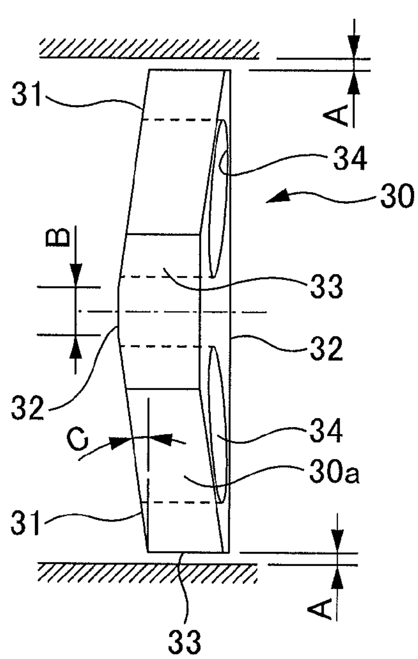
FIG. 4


31
A
34
30
B
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32
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C
34
30a
31
A
33

FIG. 5

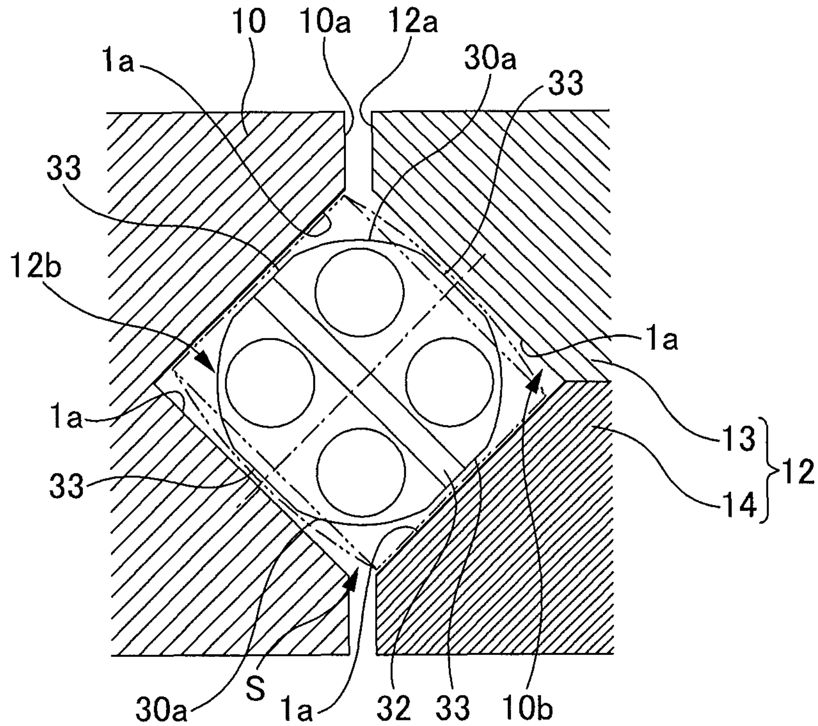
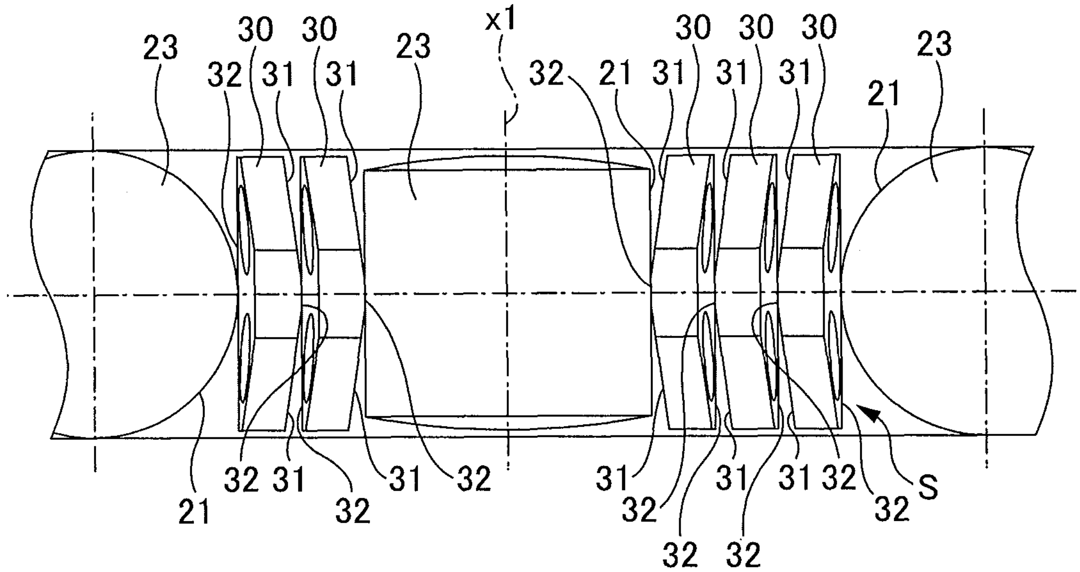


FIG. 6



23
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30
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x1
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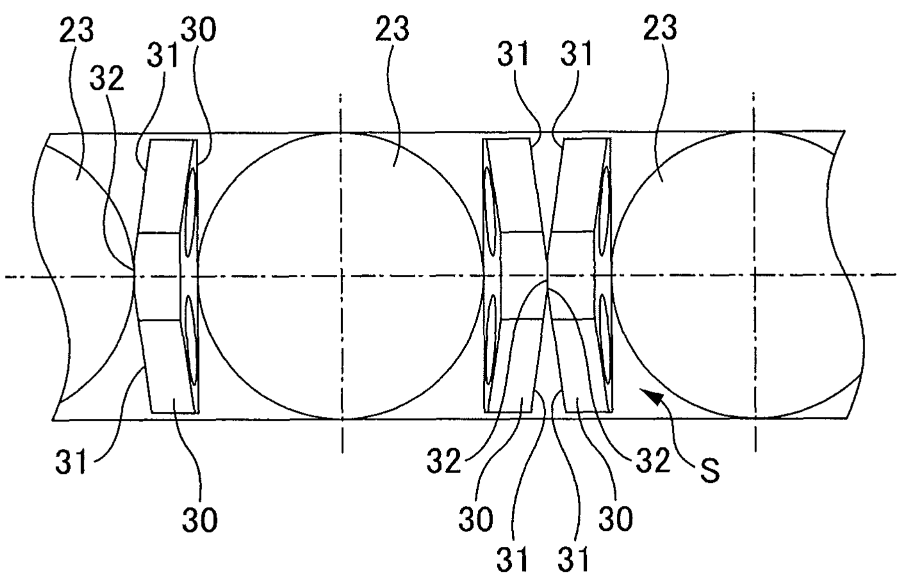
FIG. 7



23
30
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23
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FIG. 8

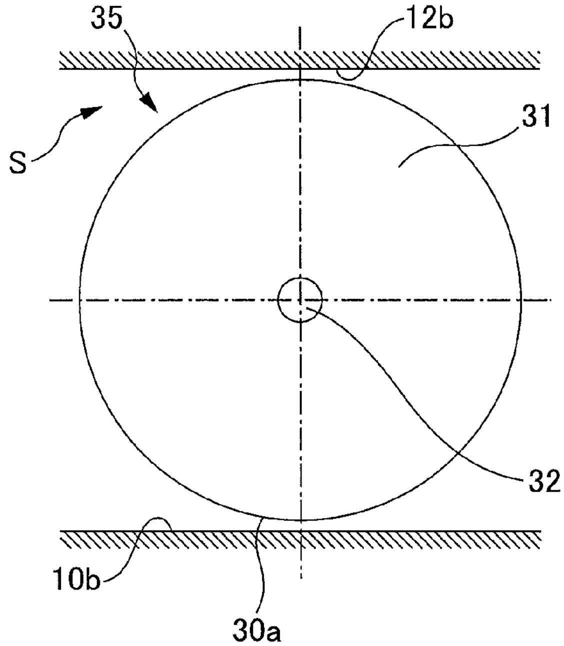

FIG. 9A

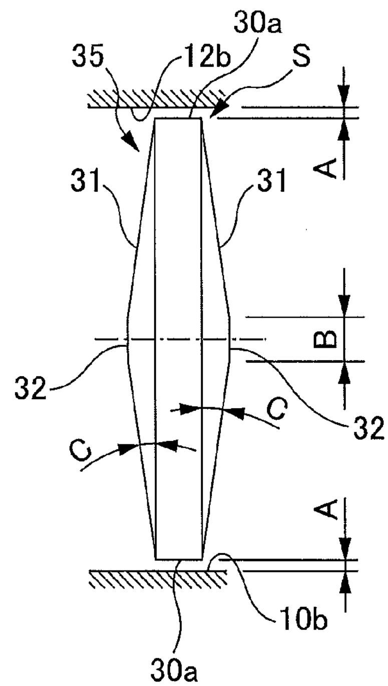

FIG. 9B

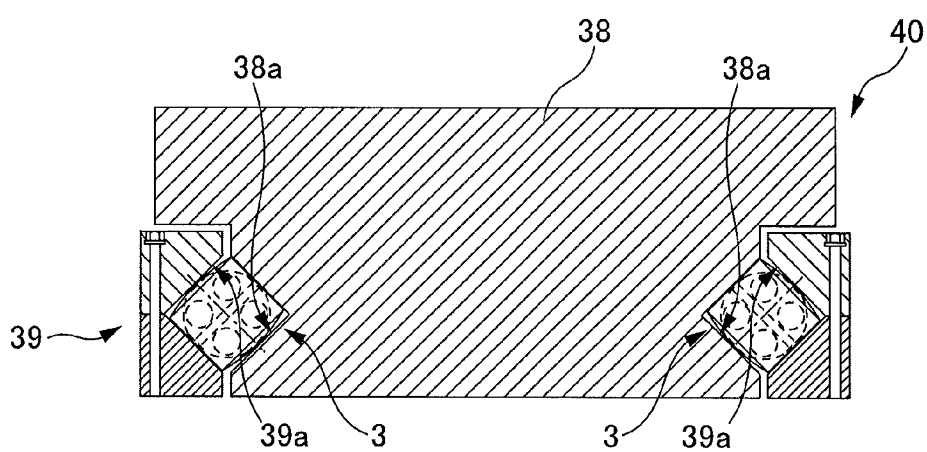

FIG. 10

CROSSED ROLLER BEARING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a 371 U.S. National Stage of International Application No. PCT/JP2012/080747, filed Nov. 28, 2012, which claims priority to Japanese Patent Application No. 2011-264795, filed Dec. 2, 2011. The disclosures of the above applications are incorporated herein by reference.

TECHNICAL FIELD

The invention relates to a crossed roller bearing whose inner element and outer element relatively rotate.

BACKGROUND ART

As a crossed roller bearing in which an inner element and an outer element relatively rotate, the following slewing bearing is known: the slewing bearing includes multiple rollers and spacer retainers; the multiple rollers are placed between V-grooves facing each other so that the inclination directions in which adjacent rollers (rolling elements) are each inclined are alternately perpendicular to each other and so that the projected center lines of the rollers is directed towards the centers of inner and outer rings, the projected center lines being obtained by projecting the straight lines aligned with the axes of the rollers respectively onto the plane of rotation of inner and outer rings; and spacer retainers are placed between adjacent rollers in order to prevent skewing (shifting in a certain direction) of the rollers, each of the spacer retainers having concave grooves which the adjacent rollers rotatably fit. In the concave grooves, tilted contact surfaces are provided respectively for each of the rollers, each of the tilted contact surfaces having a vertex at the center in its longitudinal direction and tilts at half the angle between the projected center lines of the adjacent rollers (i.e., [PTL 1]).

CITATION LIST

Patent Literature

[PTL 1] Japanese Unexamined Utility Model Application Publication No. H1-156314

SUMMARY OF THE INVENTION

Technical Problem

In the conventional slewing bearing mentioned above, the tilted contact surfaces on which the spacer retainers fit the rollers are each a three-dimensional surface, which needs to be very particularly accurately machined. In addition, there is a possibility that spaces may exist depending on conditions of the position where each spacer retainer is placed. In this case, in order to eliminate such spaces, it is sometimes necessary to use multiple types of spacer retainers having three-dimensional surfaces each of which fits the spaces. In this type of slewing bearing, since it is complicated to assemble multiple rollers and multiple spacer retainers, there is a problem that increasing the types of the spacer retainers makes assembly operations more complicated.

The invention has been made in view of the above problems, and an advantage thereof is to provide a crossed roller bearing which is easy to be assembled and can prevent skewing of its rolling elements.

Solution to Problem

An aspect of the invention to achieve the above advantage is a crossed roller bearing, including:

an inner element and an outer element that relatively rotate,
- the inner element including an annular inner V-groove
  - that is provided along an outer peripheral surface of the inner element and
  - that has a V shape that opens towards the outer element,
- the outer element including an annular outer V-groove
  - that is provided along an inner peripheral surface of the outer element,
  - that has a V shape that opens towards the inner element, and
  - that faces the inner V-groove;

a plurality of cylindrical rolling elements
- that are placed between the inner V-groove and the outer V-groove,
- that roll while being in contact with the inner V-groove and the outer V-groove, and
- adjacent rolling elements of which have rolling axes that are perpendicular to each other; and

a retainer
- that are placed between the adjacent rolling elements that includes
  - a flat section that is a projecting central section on an area which faces either one of the rolling elements and that is capable of contact with the rolling element, and
  - a tilt section whose degree of projection becomes smaller as it goes from the flat section to an end section of the retainer.

Other features of this invention will become apparent from the description in this specification and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross-sectional view showing an example of a crossed roller bearing according to the invention.

FIG. **2** is a conceptual diagram showing rollers provided in the crossed roller bearing of the present embodiment.

FIG. **3** is a diagram showing how rollers and retainers are provided in a race space.

FIG. **4** is a diagram showing the retainer as viewed from a direction along the race space.

FIG. **5** is a diagram showing the retainer as viewed from a direction intersecting the race space.

FIG. **6** is a diagram showing the retainer placed in the race space.

FIG. **7** is a diagram illustrating additional retainers provided in an empty space between a retainer and a roller.

FIG. **8** is a diagram of a retainer when the rolling axes of the rollers adjacent to the retainer point in the same direction.

FIG. **9** is a diagram showing a modified example of a retainer: FIG. **9***a* is a view from a direction along the race space; and FIG. **9***b* is a view from a direction intersecting the race space.

FIG. **10** is a cross-sectional view of a crossed roller bearing provided on a device.

MODE FOR CARRYING OUT THE INVENTION

From the description in the detailed description of the invention and the accompanied drawings, at least the following matters will be apparent.

A crossed roller bearing includes: an inner element and an outer element that relatively rotate, the inner element including an annular inner V-groove that is provided along an outer peripheral surface of the inner element and that has a V shape that opens towards the outer element, the outer element including an annular outer V-groove that is provided along an inner peripheral surface of the outer element, that has a V shape that opens towards the inner element, and that faces the inner V-groove; a plurality of cylindrical rolling elements that are placed between the inner V-groove and the outer V-groove, that roll while being in contact with the inner V-groove and the outer V-groove, and adjacent rolling elements of which have rolling axes that are perpendicular to each other; and a retainer that are placed between the adjacent rolling elements that includes a flat section that is a projecting central section on an area which faces either one of the rolling elements and that is capable of contact with the rolling element, and a tilt section whose degree of projection becomes smaller as it goes from the flat section to an end section of the retainer.

With such a crossed roller bearing, the plurality of cylindrical rolling elements are placed between the annular inner V-groove and the annular outer V-groove, and the retainer that is placed between the adjacent rolling elements of these rolling elements includes the flat section having the projecting central section capable of contact with the rolling element, on the area which faces either one of the rolling elements. This allows all the rolling elements and all the retainers to be in contact with each other at a substantially radially middle point in a space, the space being formed by the annular, inner V-groove and outer V-groove and being contact with the rolling elements when rolling. In this case, since the space in which the rolling elements are rolling while being in contact with the V-grooves has an annular shape, the distance between adjacent rolling elements is small on the side close to the center in the radial direction, and is large on the side away from the center. Therefore, if each retainer is flat, the retainer and the rolling element are in contact with each other at a position close to the center. This is likely to cause skewing of the rolling element towards the outer element. Therefore, the projecting central section, as in the retainer of the crossed roller bearing according to the invention, makes it possible to keep the appropriate distance between adjacent rolling elements while preventing skewing of the rolling elements.

Further, the retainer includes the tilt section whose degree of projection becomes smaller as it goes from the flat section located in the center to the end section. This makes it possible to prevent the sections except the flat section from coming into contact with the rolling elements.

Furthermore, since the surface of the retainer, where the retainer and the rolling element are in contact, is flat, the contact section with the cylindrical rolling element is linear. This makes it possible to provide a high resilient, crossed roller bearing which can further prevent abrasion of the retainer than when the retainer and the rolling element are in contact at a point.

In such a crossed roller bearing, it is desirable that the flat section has a strip-like shape and extends in a direction perpendicular to the rolling axis of the rolling element that the flat section faces.

With such a crossed roller bearing, since the flat section has a strip-like shape and extends in a direction perpendicular to the rolling axis, the position at which the flat section is in contact with the rolling element does not shift in a direction along the rolling axis even if the rolling element shifts in a direction intersecting the rolling axis. This makes it possible to keep the appropriate distance between adjacent rolling elements without exerting on the rolling element a force which causes skewing of the rolling element towards the outer element.

In such a crossed roller bearing, it is desirable that two flat sections are respectively provided in two areas facing the rolling elements between which the retainer is placed, and the two strip-like flat sections are perpendicular to each other.

With such a crossed roller bearing, since the rolling axes of adjacent rolling elements are perpendicular to each other, the strip-like flat sections can be respectively in contact with the adjacent rolling elements while the flat sections being perpendicular to each of rolling axes. This makes it possible to keep the appropriate distance between adjacent rolling elements without exerting any of the adjacent rolling elements a force which causes skewing.

In such a crossed roller bearing, it is desirable that the retainer is unrotatably provided.

With such a crossed roller bearing, since the retainer itself does not rotate, the position at which a rolling element adjacent to the retainer is in contact with the flat section of the retainer does not shift greatly. Also, relative orientation does not change greatly. This makes it possible to provide an efficient, crossed roller bearing which rotates more smoothly while keeping the flat section and the rolling element in proper contact with each other.

In such a crossed roller bearing,

the retainer may have a disk shape, and

the flat section may have a circular shape and be formed at the central section.

With such a crossed roller bearing, the flat sections of the retainer have a circular shape and are formed at the central section. So, the retainer can be arranged between the adjacent rolling elements regardless of its orientation with respect to the rolling axes. This makes it possible to keep the appropriate distance between adjacent rolling elements while preventing skewing of the rolling elements. In addition, a crossed roller bearing which is easy to be assembled can be provided.

In such a crossed roller bearing, it is desirable that grease fills between the inner V-groove and the outer V-groove, and the retainer includes a through hole on an area in which the flat section does not exist, the through hole extending through the retainer in a direction in which the flat section projects.

With such a crossed roller bearing, it is possible to cause grease filling between the inner V-groove and the outer V-groove to successfully circulate through the through holes when the rolling elements and the retainers move between the inner V-groove and the outer V-groove by the relative rotation of the inner element and the outer element of the crossed roller bearing. That is, it is possible to hold excess grease in the through holes while preventing the excess grease from remaining between the rolling element and the retainer. Further, providing through holes can reduce materials for manufacturing the retainer, which results in cost reduction.

In such a crossed roller bearing, it is desirable that the retainers the number of which is determined by a distance between the adjacent rolling elements are placed.

With such a crossed roller bearing, since retainers the number of which is determined by the distance between each pair of adjacent rolling elements are placed between the pair of adjacent rolling elements, it is possible to make spaces between each pair of adjacent rolling elements smaller. This makes it possible to provide a crossed roller bearing which rotates more smoothly.

A crossed roller bearing associated with an embodiment of the invention will be described below.

<<< Overview >>>

A common crossed roller bearing has the following configuration: the main elements are a plurality of rolling elements which each have a cylindrical shape or a roller-like shape and whose rolling axis is directional; and the plurality of rolling elements are arranged along the circumferential direction at certain intervals in an annular space between an inner element and an outer element which relatively rotate. The plurality of rolling elements roll, for example, between the inner race section of the inner element and the outer race section of the outer element. Particularly, in the crossed roller bearing, each rolling element is placed in an inclined manner so that its rolling axis is directed towards the rotational axis about which the inner element and the outer element rotate and so that the inclination direction of its rolling axis is perpendicular to the direction of the rolling axes of the adjacent rolling elements. Retainers are provided between the inner element and the outer element for holding the rolling elements which roll between the outer and inner elements.

The above configuration will be described according to the present embodiment. FIG. **1** is a cross-sectional view showing an example of a crossed roller bearing according to the invention.

A roller **23**, which serves as a rolling element used in the crossed roller bearing **1** of the present embodiment, has a cylindrical shape and includes a cylindrical rolling surface **21** and a pair of curved end surfaces **22** on both ends of the rolling surface **21**, the curved end surface **22** being convex outward. A plurality of the rollers **23** are circumferentially spaced in an annular space between an inner ring **10** and an outer ring **12**; the inner ring **10** serves as the inner element, and the outer ring **12** is provided outside the inner ring **10** and serves as the outer element.

The plurality of rollers **23** roll between an inner V-groove **10***b* and an outer V-groove **12***b*: the inner V-groove **10***b* is an annular groove extending along the outer peripheral surface **10***a* of the inner ring **10** and has a V-shape with the point of the V extending towards the outer ring **12**; and the outer V-groove **12***b* is an annular groove extending along the inner peripheral surface **12***a* of the outer ring **12**, faces the inner V-groove **10***b*, and has a V-shape with the point of the V extending towards the inner ring **10**.

The outer ring **12** is composed of a first ring element **13** and a second ring element **14** which each have a ringlike shape and are arranged facing each other in the rotation axial direction of the crossed roller bearing **1**. The first ring element **13** and the second ring element **14** are integrated by fixing bolts **15**.

On the inner-ring-**10** side of the opposing surfaces of the first ring element **13** and the second ring element **14**, a track surface **1***a* are provided along its circumferential direction. Each of the track surfaces **1***a* comes into contact with the rolling surface **21** of each roller **23**, or faces the curved end surface **22** with a narrow spacing of 0.1 mm, for example; each roller **23** is placed in an inclined manner so as to be directed towards the rotation axis **x2** of the crossed roller bearing **1**. By integrating the first ring element **13** and the second ring element **14** with the fixing bolts **15**, the track surface **1***a* of the first ring element **13** and the track surface **1***a* of the second ring element **14** are provided in the form of a V to form the outer V-groove **12***b*. The outer V-groove **12***b* guides the rolling of the rollers **23** from the outside.

Similarly, the inner peripheral surface **12***a* of the outer ring **12** faces the outer peripheral surface **10***a* of the inner ring **10**, and the inner V-groove **10***b* is provided in the form of a V along its circumferential direction. The inner V-groove **10***b* comes into contact with the rolling surface **21** of each inclined roller **23**, or faces the curved end surface **22** with a narrow spacing. Thus, the inner V-groove **10***b* guides the rolling of the rollers **23** from the inside.

FIG. **2** is a conceptual diagram showing rollers provided in the crossed roller bearing of the present embodiment. FIG. **3** is a diagram showing how rollers and retainers are provided in a race space.

The rollers **23** are placed between the inner V-groove **10***b* and the outer V-groove **12***b* in an inclined manner so that the rolling axes **x1** of the rollers **23** are directed towards the rotation axis **x2** of the inner ring **10** and so that the inclination direction of the rolling axes **x1** of adjacent rollers **23** are perpendicular to each other as shown in FIG. **2**. A retainer **30** is placed between each pair of adjacent rollers **23**, as omitted in FIG. **2** but shown in FIG. **3**. Further, grease (not shown) fills between the inner V-groove **10***b* and the outer V-groove **12***b*.

FIG. **4** is a diagram showing the retainer as viewed from a direction along the race space. FIG. **5** is a diagram showing the retainer as viewed from a direction intersecting the race space.

The retainer **30** is a member made of resin having substantially a disk shape. As shown in FIGS. **4** and **5**, on the outer periphery of the retainer **30**, there are formed pairs of peripheral parallel surfaces **33** extending in parallel in two directions which are perpendicular to each other through the center o of the retainer **30**. That is, the retainer **30** has a shape in which four arcs are removed from the disk-shaped outer periphery.

FIG. **6** is a diagram showing a retainer placed in the race space.

In the race space S whose longitudinal cross-section is substantially rectangular and which is formed by the inner V-groove **10***b* and the outer V-groove **12***b*, when the retainers **30** is placed between a pair of adjacent rollers **23**, the four peripheral parallel surfaces **33** of each retainer **30** respectively face four track surfaces **1***a* in the race space S with a narrow space (e.g., 0.1 mm), as shown in FIG. **6**.

In the central section on both surfaces of the retainer **30**, a strip-like flat section **32** is provided extending along the straight line passing the center o and extending across one of two pairs of the peripheral parallel surfaces **33** on the outer periphery. The flat sections **32** extend in different directions depending on the surfaces of the retainer **30**; the direction of the flat section **32** on one surface is perpendicular to the direction of the flat section **32** on the other surface. Also, the retainer **30** has tilt sections **31** which are tilted from the flat sections **32** towards the end sections **30***a* so that the retainer **30** becomes thinner. That is, the flat sections **32** provided on the central section of the retainer **30** are projected outward, and the tilt section **31** is tilted, which the degree of projection becomes smaller as it goes from the flat sections **32** to the end sections **30***a*. In this case, the width B of the flat section **32** is greater than or equal to 2A, that is, the total (the two places) of the distance A from the peripheral parallel surface **33** of the retainer **30** to the track surface **1***a* of the inner ring **10** or the outer ring **12**. Further, the tilt sections **31** extend from the flat section **32** to the end section **30***a* of the retainer **30** as mentioned above, and the tilt angle C thereof is larger than the angle θ, half the angle 2θ between straight lines from the center O of the crossed roller bearing **1** to the rolling axes x**1** of the adjacent rollers **23** between which the retainer **30** is placed, as shown in FIG. **3**.

Further, on the tilt section **31** of the retainer **30**, that is, on areas in which the flat sections **32** do not exist, holes **34** are provided as through holes extending through the retainer **30** in a direction in which the flat sections **32** are projected. Each of these holes **34** serves as a flow path through which grease filling the race space S moves when the rollers **23** and the retainers **30** move in the race space S by the relative rotation of the inner ring **10** and the outer ring **12** of the crossed roller bearing **1**. In addition, the hole **34** has a function to hold excess grease.

The retainer **30** which is placed between a pair of adjacent rollers **23** is arranged so that the rolling axis x**1** of each roller **23** facing one of the flat sections **32** of the retainer **30** is respectively perpendicular to the direction in which the strip-like flat section **32** extends. In this case, the adjacent rollers **23** are arranged so that their rolling axes x**1** are perpendicular to each other. In addition, the flat section **32** on one surface of the retainer **30** is perpendicular to the flat section **32** on the other surface. Therefore, if the number of the rollers **23** included in the crossed roller bearing **1** is even, the retainer **30** is arranged so that a direction in which each flat section **32** extends on each surface of the retainer **30** is perpendicular to the rolling axis x**1** of each roller **23**.

FIG. **7** is a diagram illustrating additional retainers provided in an empty space between a retainer and a roller. FIG. **8** is a diagram of a retainer when the rolling axes of the rollers adjacent to the retainer point in the same direction.

When the rollers **23** and the retainers **30** are alternately arranged in the race space S, if an empty space is large between a certain retainer **30** and a certain roller **23**, it is desirable that an additional retainer **30** pointing in the same direction as the certain retainer **30** is arranged in the empty space, as shown in FIG. **7**.

If the number of the rollers **23** included in the crossed roller bearing **1** is odd, the rolling axes x**1** of any one of pair of adjacent rollers **23** are in the same direction. So, as shown in FIG. **8**, an additional retainer **30** is placed between the retainer **30** and the roller **23** so that flat sections **32** of both retainers **30** extending in the same direction faces.

In the crossed roller bearing **1** of the present embodiment, there are a plurality of cylindrical rollers **23** between the inner V-groove **10***b* and the outer V-groove **12***b*, both of the inner V-groove **10***b* and the outer V-groove **12***b* having an annular shape. The retainer **30** is placed between adjacent ones of the plurality of the rollers **23**, and includes flat sections **32**; each flat section **32** is a projecting central section on an area which faces either of the adjacent rollers **23** and the central section can be in contact with the roller **23**. This allows all the rollers **23** and all the retainers **30** to be in contact with each other at a substantially radially middle point in the race space S, the race space S being formed by the annular, inner V-groove **10***b* and outer V-groove **12***b* and being contact with the rollers **23** when rolling. In this case, since the race space S in which the rollers **23** are rolling while being in contact with the V-grooves has an annular shape, the distance between adjacent rollers **23** is small on the side close to the center O in the radial direction, and is large on the side away from the center. Therefore, if each retainer **30** is flat, the retainer **30** and the roller **23** are in contact with each other at a position close to the center. This is likely to cause skewing of the roller **23** towards the outer ring **12**. Therefore, the projecting central section, as in the retainer **30** of the crossed roller bearing **1** according to the invention, makes it possible to keep the appropriate distance between adjacent rollers **23** while preventing skewing of the rollers **23**.

Further, the retainer **30** includes the tilt section **31** whose degree of projection becomes smaller as it goes from the flat section **32** located in the center to the end section **30***a*. This makes it possible to prevent the sections except the flat section **32** from coming into contact with the rollers **23**.

Furthermore, since the flat section **32** of the retainer **30**, where the retainer **30** and the roller **23** are in contact, is flat, the contact section with the cylindrical roller **23** is linear. This makes it possible to provide a high resilient, crossed roller bearing **1** which can prevent abrasion of the retainer **30** than when the retainer **30** and the roller **23** are in contact at a point.

Since each flat section **32** has a strip-like shape and extends in a direction perpendicular to the rolling axis, the position at which the flat section **32** is in contact with the roller **23** does not shift in a direction along the rolling axis even if the roller **23** shifts in a direction intersecting the rolling axis. This makes it possible to keep the appropriate distance between adjacent rollers **23** without exerting on the roller **23** a force which causes skewing of the roller **23** towards the outer ring **12**.

Since the rolling axes x**1** of adjacent rollers **23** are perpendicular to each other, the strip-like flat sections **32** can be respectively in contact with the adjacent rollers **23** while the flat sections **32** being perpendicular to each of the rolling axes x**1**. This makes it possible to keep the appropriate distance between adjacent rollers **23** without exerting any of the adjacent rollers **23** a force which causes skewing.

Since the peripheral parallel surface **33** of the retainer **30** faces with a narrow spacing the track surface **1***a* which forms the race space S, the retainers **30** cannot rotate. That is, since the retainer **30** itself does not rotate, the position at which a roller **23** adjacent to the retainer **30** is in contact with the strip-like flat section **32** of the retainer **30** does not shift greatly. Also, relative orientation does not change greatly. This makes it possible to provide an efficient, crossed roller bearing **1** which rotates more smoothly while keeping the retainers **30** and the rollers **23** in proper contact with each other. Further, since the retainer **30** cannot rotate, there is less friction between the inner V-groove **10***b* and the outer V-groove **12***b*, so that unnecessary load is not generated. This makes it possible to provide a more efficient, crossed roller bearing **1**.

Since each retainer **30** has holes **34**, grease filling the race space S can circulate through these holes **34** when the rollers **23** and the retainers **30** move in the race space S by the relative rotation of the inner ring **10** and the outer ring **12** of the crossed roller bearing **1**.

More specifically, if the retainers have no hole, when the retainers move in the race space S, most of grease filling in the race space S gathers and remains in the four corners of the race space S in such a manner that the grease is pushed by projecting flat sections and tilt surfaces, which form both surface of each retainer. Simultaneously, since grease in the race space S is replenished in excess, the retainers always push grease when moving. Therefore, it is possible that frictional torque during rotation is increased by grease-derived pressure and becomes load. In addition, it is possible that abnormal sound is generated because of rubbing sound caused by high-speed movement of the retainers and grease.

If each retainer has a projecting center part and does not include holes as in the above embodiment, grease is less likely to remain on the projecting flat section of the retainer. So, it is difficult to hold grease in the vicinity of a section contacting with the roller. Providing holes **34** on each retainer **30** as in the above embodiment enables these holes **34** to serve as escape places for grease during the rotation of the crossed roller bearing **1**. This makes it possible to reduce load caused by the grease during the rotating. Also, since the holes **34** can hold a large amount of grease, excess grease in the race space S can be kept in the holes **34**, and it is possible to hold grease in the vicinity of the flat section **32** which is in contact with the roller **23**. This makes it possible to maintain more desirable contact between the roller **23** and the retainer **30**.

Providing holes **34** can reduce materials for manufacturing the retainers **30**, which results in cost reduction.

Further, since the retainers **30** the number of which is determined by the distance between each pair of adjacent rollers **23** are placed between the pair of rollers, the space between each pair of the adjacent rollers **23** can be reduced. This makes it possible to provide a crossed roller bearing **1** which rotate more smoothly.

=== Other Embodiments ===

The above embodiment is for facilitating understanding of the invention and is not intended to limit the interpretation of the invention. The invention can of course be altered and improved without departing from the gist thereof, and equivalents are intended to be embraced therein. Particularly, the following embodiments are also included in the invention.

FIG. **9** is a diagram showing a modified example of a retainer: FIG. **9***a* is a view from the direction along the race space; and FIG. **9***b* is a view from the direction intersecting the race space.

The embodiment mentioned above provides the example of a crossed roller bearing **1** in which the retainers **30** include the peripheral parallel surfaces **33** and the strip-like flat sections **32** and the retainers **30** cannot rotate. However, as shown in FIG. **9**, a retainer **35** may have a disk shape and may include circular flat sections **32** at the center. In this case, since the flat sections **32** of the retainer **35** has a circular shape and is formed at the central section, the retainer **35** can be arranged between the adjacent rollers **23** regardless of its orientation with respect to the rolling axes x**1**. This makes it possible to keep the appropriate space between adjacent rollers **23** while preventing skewing of the rollers **23**. In addition, a crossed roller bearing **1** which is easy to be assembled can be provided.

FIG. **10** is a cross-sectional view of a crossed roller bearing provided on a device.

In the embodiment mentioned above, the crossed roller bearing **1** including the inner ring **10** and the outer ring **12** is described. However, the invention is not limited thereto. For example, as shown in FIG. **10**, the following crossed roller bearing **3** directly provided on a device **40** is also acceptable: a rotational element **38** which rotates is provided instead of the inner ring; an inner V-groove **38***a* is provided directly on the outer peripheral surface of the rotational element **38**; a support member **39** which supports the rotational element **38** is included instead of the outer ring **12**; and an outer V-groove **39***a* is provided on the support member **39**.

In the embodiment mentioned above, the example in which the outer ring **12** and the support member **39** are separated is described. However, the configuration in which the inner ring **10** and the rotational element **38** are separated is also acceptable.

Further, in the embodiment mentioned above, the crossed roller bearing **1** including the annular race space S which rotates is described. However, the invention is not limited thereto. For example, this invention may be applied a linear guide which uses a linear crossed roller including a straight race space S.

REFERENCE SIGNS LIST

1 crossed roller bearing, **1***a* track surface,
3 crossed roller bearing, **10** inner ring, **10***a* outer peripheral surface,
10*b* inner V-groove, **12** outer ring, **12***a* inner peripheral surface,
12*b* outer V-groove, **13** first ring element,
14 second ring element, **15** fixing bolt, **21** rolling surface,
22 curved end surface, **23** roller, **30** retainer, **30***a* end sections of retainer, **31** tilt section, **32** flat section, **33** peripheral parallel surface, **34** hole, **35** retainer, **36** flat section, **37** narrow groove, **38** rotational element, **38***a* inner V-groove, **39** support member, **39***a* outer V-groove, **40** device, x**1** rolling axis, x**2** rotation axis, A distance between peripheral parallel surface and track surface, B width of flat section, C tilt angle, O center of rotation, o center of retainer, S race space

The invention claimed is:

1. A crossed roller bearing, comprising:
an inner element and an outer element that relatively rotate,
the inner element including an annular inner V-groove
that is provided along an outer peripheral surface of the inner element and
that has a V shape that opens towards the outer element,
the outer element including an annular outer V-groove
that is provided along an inner peripheral surface of the outer element,
that has a V shape that opens towards the inner element, and
that faces the inner V-groove;
a plurality of cylindrical rolling elements
that are placed between the inner V-groove and the outer V-groove,
that roll while being in contact with the inner V-groove and the outer V-groove, and
adjacent rolling elements of which have rolling axes that are perpendicular to each other; and
a plurality of retainers
that are placed between the adjacent rolling elements,
that include
a flat section that is a projecting central section on an area which faces either one of the rolling elements and that is capable of contact with the rolling element, and
a tilt section whose degree of projection becomes smaller as it goes from the flat section to an end section of the retainers.

2. A crossed roller bearing according to claim **1**, wherein the flat section has a strip-like shape and extends in a direction perpendicular to the rolling axis of the rolling element that the flat section faces.

3. A crossed roller bearing according to claim **2**, wherein two strip-like flat sections are respectively provided in two areas facing the rolling elements between which the retainer is placed, and
the two strip-like flat sections are perpendicular to each other.

4. A crossed roller bearing according to claim **1**, wherein the retainers are unrotatably provided.

5. A crossed roller bearing according to claim **1**, wherein the retainers have a disk shape, and
the flat section has a circular shape and is formed at the central section.

6. A crossed roller bearing according to claim **1**, wherein grease fills between the inner V-groove and the outer V-groove, and

the retainers include a through hole on an area in which the flat section does not exist, the through hole extending through the retainer in a direction in which the flat section projects.

7. A crossed roller bearing according to claim **1**, wherein a number of the retainers placed between the adjacent rolling elements is determined by a distance between the adjacent rolling elements.

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